REMARKS

In the above reference case, Claims 1-15 are pending. Applicant would like to thank the Examiner for the thorough examination of the pending claims and thoughtful comments, and for granting a subsequent telephonic interview. Applicant will sequentially address the issues raised by the Examiner in the Office Action.

I. Interview Summary

The telephonic interview was conducted between the Examiner, Ms. Kamini Shah (SPE), Applicant and the undersigned (representative of the Applicant) on June 1, 2007. No exhibit was used. The 35 U.S.C. §101, §102 and §112 rejections regarding claim 1, and drawings objection were discussed. An agreement has been reached as to overcome the §112 rejection with a proposed amendment to claim 1 presented by Applicant. The SPE and the Examiner made a suggestion of adding a result to claim 1, such that the amended claim 1 would overcome the 101 rejections. Although there was no definitive agreement regarding the §102 rejections with respect to cited reference (Nagtegaal, US Patent No.: 6,044,210), Applicant and the undersigned appreciate the opportunity to understand the interpretation of the Examiner on the claims.

II. Claim Status

Claims 1, 2, 6, 7, and 11-15 have been amended. No new matters have been added. Claims 11-15 have been amended to a set of system claims with substantially similar limitations of respective claims 1-5.

The new limitation in the independent claims 1, 6 and 11 are supported by respective limitations from claims 2, 7 and 12 and by the descriptions in paragraph [0055] of the Specification of the instant application. Claims 2, 7 and 12 have been amended to reflect those limitations being added to the respective independent claims 1, 6 and 11. Claims 1, 2, 4, 6, 7, 9, 11, 12 and 14 have been amended to clarify the local initial element coordinate systems

and the local current element coordinate system. Support of these added clarifications can be found in paragraphs [0042] and [0043]. Claims 13-15 have been amended to be a proper dependent claims directly or indirectly to claim 11. As a result, claims 1-15 are now pending.

III. Drawings Objection

As indicated in the amendment to the drawings above, FIGS. 1A, 1B, 2A, 2B and 6 have been amended in response to the Examiner's suggestion in the current Office Action. The Examiner also objected FIGS. 5A-5H as allegedly being "Prior Art" without stating any reason. Applicant submits that FIGS. 5A-5H contain a new feature used in the present invention. In particular, FIGS. 5A-5H list the equations used in the claimed method (i.e., claims 1-5). The detailed descriptions of FIGS. 5A-5H are found in paragraphs [0058] and [0059] of the Specification of the instant application. Therefore, withdrawal of the objection to the drawings is respectfully requested. If the Examiner would maintain the same objection to FIGS. 5A-5H, Applicant respectfully requests that the Examiner establishes a *prima facie case*.

IV. The 35 U.S.C. §112 Rejections

Claims 1-15 were rejected under 35 U.S.C. §112 as allegedly being incomplete. The currently amended independent claims 1, 6 and 11 recite a new limitation, "calculating a set of counter nodal forces in the current element coordinate system from the generalized hourglass forces and the hourglass shape vectors, wherein the set of counter nodal forces is used to offset the hourglass deformations such that the hourglass deformations are controlled in the finite element analysis of the structural product" *(emphasis added)*, which shall overcome the missing step for controlling hourglass deformation of a solid element in finite element analysis. The new limitation, "the set of counter nodal forces is used to resist the hourglass deformations", is added to further clarify the claimed invention calculates a set of counter nodal forces that is applied to offset the hourglass deformations in each

solution cycle of a finite element analysis of a structural product (e.g., automobile, train, motorcycle, airplane, etc.). Each and every one of the dependent claims depends directly or indirectly on the independent claims 1, 6 and 11, hence containing at least the above stated reason for overcoming the 112 rejection. Therefore, Applicant submits claims 1-15 shall overcome the 112 rejection. Withdrawal of the 112 rejections is respectfully requested.

V. The 35 U.S.C. §101 Rejections

Claims 1-15 were rejected under 35 U.S.C. §101 as allegedly being directed to non-statutory subject matter. The currently amended independent claims 1, 6 and 11 include a new feature in the preamble: "for controlling hourglass deformations of a solid element in a finite element analysis for designing and analyzing a structural product", which shows the method or program code providing instructions to the method is used for designing and analyzing a structural product such as an automobile. In addition, a new limitation of claim 1 is reproduced as follows: "… wherein the set of counter nodal forces is used to offset the hourglass deformations such that the hourglass deformations are controlled in the finite element analysis of the structural product" (*emphasis added*). Because the present invention enables the control of the hourglass deformations in a finite element analysis of a structural product such as an automobile or airplane, the finite element analysis results can be used to study the physical behavior of the structural product when it is subjected to prescribed loads such as a surface forces, body forces and/or prescribed motions. If hourglass deformations are not controlled, their magnitude can grow very large relative to other modes of deformation thereby rendering the analysis results unusable due to large error in the deformed shape of the structural products. Therefore, the claimed invention has a useful, tangible real world value (e.g., reduce automobile design time) and result (e.g., meaningful numerical analysis for designing an automobile and its components). All of the dependent claims depend directly or indirectly to the independent claims. Therefore, Applicant believes that

claims 1-15 shall overcome the 101 rejections. Reconsideration of claims 1-15 are respectfully requested.

VI. The 35 U.S.C. §102(b) Rejections

Claims 1, 6 and 11 were rejected under 35 U.S.C. §102(b) as allegedly being anticipated by Nagtegaal US Patent No.: 6,044,210, (hereinafter "Nagtegaal"). Applicant respectfully traverses the rejection.

A. Brief Summary of the Present Invention

Hourglass deformation control in finite element analysis has been used for many years. The traditional approaches to control hourglass deformation calculate hourglass forces by an incremental method which uses the incremental movement of the nodes during a solution cycle and the updated location of the nodes to calculate an increment of hourglass deformation. Increments are summed over time to obtain total hourglass deformation and hourglass forces are calculated to resist the total hourglass deformation. Because the element geometry changes during the solution (i.e., simulation in time), the stiffness associated with the hourglass control is variable in time which can lead to residual hourglass deformation even after the load has been removed. (paragraph [0012] of the Specification) As a result, the element may not be able to restore to its initial state after the loading has been removed. For a tire model using solid element with hyper-elastic material, this becomes a problem because the tire should always come back to its initial state after the loading has been removed.

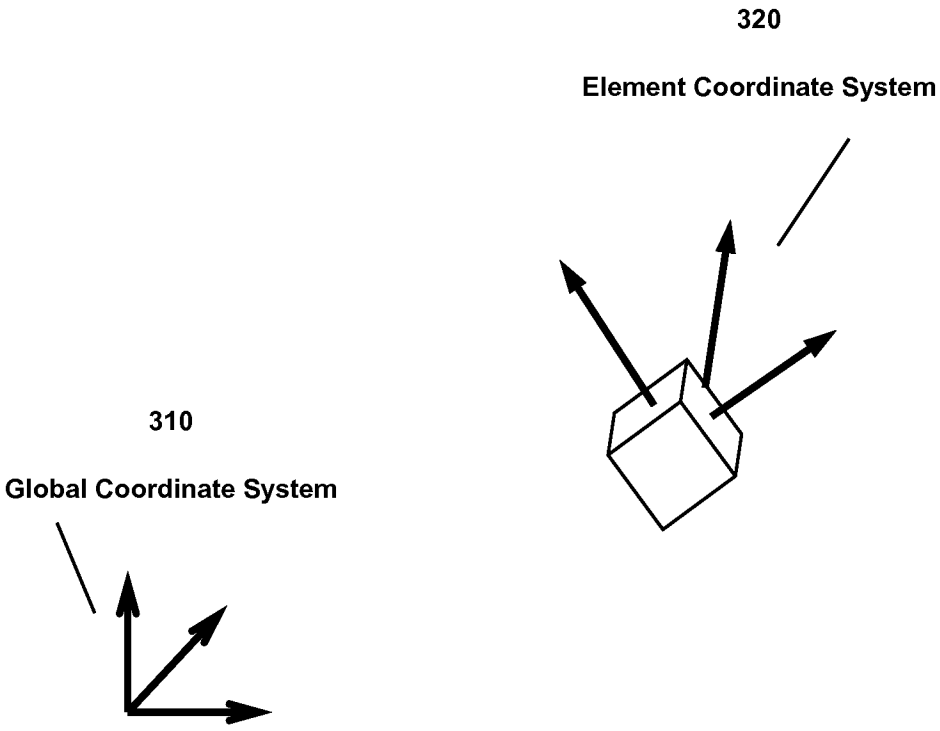
In the present invention, the set of counter nodal forces is obtained during each solution cycle by calculating the total hourglass deformation at the current solution time and subtracting from it the total hourglass deformation that existed at the start of the calculation. This

method guarantees that there will be no residual hourglass deformation when the load is removed, because the calculated hourglass deformation at the current solution time becomes equal to the calculated hourglass deformation at the initial time whenever the current geometry is equal to the initial geometry as long as the current hourglass deformation is measured in the local current element coordinate system and the initial hourglass deformation is measured in the local initial element coordinate system as indicated in formula 520 of FIG. 5A and descriptions in paragraph [0058]. Because the difference of the hourglass deformations between the current nodal coordinates in a local current element coordinate system and the initial nodal coordinates in a local initial element coordinate system is always calculated, the initial undeformed element state can be restored after the loading has been removed. The calculation also uses a set of hourglass shape vectors (i.e., Gamma vector listed in table 580 of FIG. 5C).

During the telephonic interview, it appeared that the Examiner and SPE had some confusion with regard to the following terms recited in claim 1: initial nodal coordinates, current nodal coordinates, local initial element coordinate system, local current element coordinate system, and global coordinate system. These terms are described below in detail with the intent to resolve the confusion. FIG. 3 of the Specification (reproduced below) is a diagram illustrating a global coordinate system 310 and an element coordinate system 320 (e.g., a local initial element coordinate system or a local current element coordinate system).

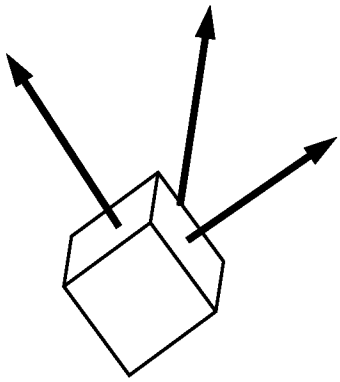
The global coordinate system is fixed in space and is used to define the entire finite element model of the structural product. The element coordinate system is fixed in an element (e.g., 8-node hexahedral solid

element). The local initial element coordinate system is established using the initial nodal coordinates of corner nodes of the solid element and the local current element coordinate system is established using the current nodal coordinates.

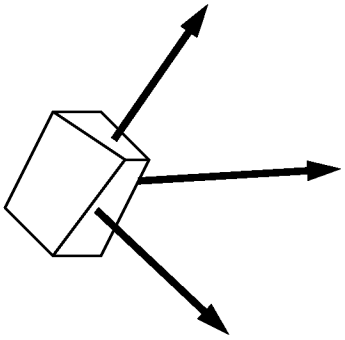


The finite element analysis in the present invention is a dynamic analysis in a time domain (i.e., simulating a structural product (e.g., car with its tires). The initial state is when time t=0, while current state is when time $t=t_{current}$. The following two diagrams show a local initial element coordinate system and a local current element coordinate system.

t=0 (local initial element coordinate system)



$t=t_{current}$ (local current element coordinate system)



Initial nodal coordinates and current nodal coordinates are the locations of 8 nodes at the corners of the solid element measured in the local initial element coordinate system and in the local current element coordinate system, respectively.

B. Independent Claim 1

It is axiomatic that the cited references in a §102 rejection must teach every element in the rejected claim. MPEP 2131. The currently amended claim 1 recites new feature(s) to further distinguish from the cited reference. In particular, specific and distinct feature(s) in the currently amended Claim 1 are set forth below:

....

calculating a set of hourglass deformation magnitudes of the solid element using the set of hourglass shape vectors and difference between the initial nodal coordinates and the current nodal coordinates of corner nodes of the solid element;

evaluating a set of generalized hourglass forces from the hourglass deformation magnitudes, the initial nodal coordinates, and material constants of the solid element; and

calculating a set of counter nodal forces in the local current element coordinate system from the generalized hourglass forces and the hourglass shape vectors, wherein the set of counter nodal forces is used to offset the hourglass deformations such that the hourglass deformations are controlled in the finite element analysis of the structural product

(*emphasis added*)

Supported in paragraphs [0015] and [0058] of the Specification of the instant application and Equation 520 in FIG. 5A, the hourglass control in the present invention is used for 8-node hexahedral elements (i.e., brick), 6-node pentahedral elements (i.e. pents) and 4-node two-dimensional plane strain and axisymmetric elements. In addition, the hourglass control used in the present invention requires two coordinate systems: a local initial element coordinate system based on the undeformed element geometry and a local current element coordinate system based on the current deformed element geometry. The set of counter nodal forces, the generalized hourglass forces and the hourglass deformation magnitudes are calculated using a difference between the current nodal coordinates and the initial nodal coordinates

of corner nodes of the solid element. Equation 5.20 is reproduced as follows:

$$\hat{g}_{i\alpha} = \sum_{J=1}^{8} \bar{\gamma}_{\alpha J}(\hat{x}_{iJ} - \overline{X}_{iJ})$$

where $\overline{X}_{iJ}$ are the initial nodal coordinates measured in the local initial element coordinate system and $\hat{x}_{iJ}$ are the current nodal coordinates measured in the local current element coordinate system. All of these nodes are corner nodes of the solid element. The solid elements applied in the present invention do not have mid-edge, mid-body, nor mid-face nodes.

In contrast, Nagtegaal teaches a special form of hourglass control applied only for a 15-node second order tetrahedral element with nodes at the corners (i.e., nodes 1-4), and at the mid-edges (i.e., nodes 5-10). (FIG. 4 Nagtegaal). Nagtegaal converts these 10 nodes into a 15-node tetrahedral by adding 5 extra nodes. The 5 extra nodes are at the mid-body (i.e., node 11) and the four mid-faces (i.e., nodes 12-15). The initial location of the mid-body node (11) is determined by Equation (1) and the node is unconstrained after that. The locations of the 4 mid-face nodes are determined throughout the calculation by Equation (2) so these nodes are effectively constrained to follow the movement of the corner nodes and mid-edge nodes. (See FIG. 4 and Lines 26-31 Column 6, Lines 1-22 Column 7 Nagtegaal). First, an hourglass strain is calculated from the difference between the location of the mid-body node (11) by the linear constraint Equation (1) and its current location using Equation (9) (See Nagtegaal Lines 34-48 Column 8). Next, an hourglass resisting force is calculated for the nodes 1 to 11 by Equations (10) and (11) (See Nagtegaal Line 48 Column 8 – Line 26 Column 9). Equation (9) of Nagtegaal (column 8 line 42) is as follows:

$$\Delta x^{HG} = -\sum_{I=1}^{11} \Gamma_I x_I$$

where x_I is nodal coordinates of the element. Γ_I are weighting factors defined in Equation (1) (**It is noted that Γ_I represents totally different items than $\gamma_{\alpha J}$ of Equation 520 of the instant application**)

By substituting the weighting factors A_{tet}, and B_{tet} into Equation (9) and expanding the summation, Equation (9) becomes the following:

$$\Delta x^{HG} = x_{11} + 0.006803282(x_1 + x_2 + x_3 + x_4) - 0.16231146(x_5 + x_6 + x_7 + x_8 + x_9 + x_{10})$$

It is evident that Equation (9) is created for a special application (i.e., control hourglass deformation for 15-node tetrahedral and nothing else). Applicant respectfully submits that applying Equation (9) to an 8-node hexahedral element or a 6-node pentahedral element would result in a meaningless mathematical calculation without any physical representation.

There are at least the following differences between Nagtegaal and the present invention:

1) Nagtegaal discloses a special form of hourglass deformation control only applied for a 15-node second order tetrahedral element, while the present invention pertains to hourglass deformation control for solid element of different types (i.e., 8-node hexahedral, 6-node pentahedral, or 4-node 2-dimensional plane strain and axisymmetric elements).
2) Nagtegaal measures hourglass deformation as the difference between the position in space of mid-body node 11 and the position in space calculated by Equation (1), (Lines 34-38 Column 8 Nagtegaal) while the present invention uses only the corner nodes.

3) Nagtegaal uses a set of weighting or scaling factors (e.g., A_{tet}, B_{tet}, A_{tri}, and B_{tri} (lines 9 and 19, column 7 Nagtegaal)) in the calculation of Equations (1) and (2) for the hourglass deformation control. The set of the weighting factors is designed for the special case (i.e., 2nd order 10-node tetrahedral element). The set of weighting factors cannot be applied to any other type of element such as the solid element recited in claim 1.

4) Nagtegaal calculates the hourglass strain with the current nodal coordinates as shown in Equation (9), while the present invention uses a difference between the current nodal coordinates and the initial nodal coordinates of corner nodes of the solid element.

Therefore, Nagtegaal does not teach, disclose nor suggest using "a difference between the initial nodal coordinates and the current nodal coordinates of corner nodes of the solid element" to calculate the set of counter nodal forces to offset hourglass deformations recited in claim 1 of the instant application. As a result, Applicant respectfully submits that claim 1 is believed to overcome the 102 rejection based on Nagtegaal. Reconsideration of claim 1 is respectfully requested.

C. Independent Claims 6 and 11

Independent claims 6 and 11 incorporate similar features recited in currently amended claim 1 and were also rejected for the similar reasons as for claim 1. Applicants would like to apply the above remarks for claim 1 to support claims 6 and 11 also. Reconsideration of Claims 6 and 11 is respectfully requested.

VII. The 35 U.S.C. §103(a) Rejections of Dependent Claims

Claims 2, 7 and 12 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nagtegaal in view of Forssell et al. :"Creating a New

Element Type",
http://web.archive.org/web/20030214185408/http://impact.sourceforge.net/Manual_Programmers/Element.html, (hereinafter "Forssell").

Claims 3-4, 8-9 and 13-14 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nagtegaal in view of Belytschko: "Element Technology", http://www.tam.northewstern.edu/tb/Book/Chapter%208.pdf, (hereinafter "Belytschko").

Claims 5, 10 and 15 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nagtegaal in view of Thomas J. R. Hughes: "The Finite Element Method Linear Static and Dynamic Finite Element Analysis", 2000, Dover Publications, (hereinafter "Hughes").

Applicant respectfully traverses the rejection.

A. Dependent Claim 2

It is axiomatic that the combination of cited references in a §103 rejection must disclose every element in the rejected claim. MPEP 2143.03. The currently amended claim 2 recites new feature(s) of the currently amended claim 1. Dependent claim 2 is dependent upon claim 1 and contains additional limitations to further distinguish them from Nagtegaal or Forssell, viewed alone or in combination. Therefore, claim 2 shall be allowable for at least the reasons stated above with regard to independent claim 1.

"Prior art disclosures on the Internet or on an on-line database are considered to be publicly available as of the date the item was publicly posted. Absent evidence of the date that the disclosure was publicly posted, if the publication itself does not include a publication date (or

retrieval date), it cannot be relied upon as prior art under 35 U.S.C. 102(a) or (b)." MPEP 2128.

Since the Examiner relied on Forssell, an Internet document without publication date, to reject claim 2. Applicant respectfully submits that the publication date of Forssell needs to be established; otherwise, Forssell does not qualify as a 102(a) or (b) reference.

B. Dependent Claims 7 and 12

Claims 7 and 12 are dependent upon respective independent claims 6 and 11 and are amended substantially similar to claim 2. Therefore, Applicant wishes to apply the same reason and submits that claims 7 and 12 shall be allowable over the cited references. Reconsideration of claims 7 and 12 are respectfully requested.

C. Dependent Claims 3-4, 8-9 and 13-14

Dependent claims 3-4, 8-9 and 13-14 are dependent upon respective independent claims 1, 6, and 11, and contain additional limitations further distinguish them from Nagtegaal or Belytschko, viewed alone or in combination. Therefore, Claims 3-4, 8-9 and 13-14 shall be allowable for at least the reasons stated above with regard to independent claim 1.

D. Dependent Claims 5, 10 and 15

Applicant respectfully disagrees with the Examiner regarding combining Nagtegaal and Hughes. Even if the cited references were combined in the manner suggested by the Examiner, the combined features do not teach the hourglass control method of the present invention.

The hourglass control technique disclosed in Nagtegaal is designed specifically for 10-node second order tetrahedral element. The technique cannot be applied to any other types of element as indicated in the following description: "The computer implemented process includes the steps of defining a finite element model for an object including at least one tetrahedral element, …." (Lines 1-3, Column 4, Nagtegaal). Hughes teaches a traditional 8-node element whose hourglass deformation cannot be controlled by the method taught in Nagtegaal. For example, Nagtegaal specifically teaches a set of weighting factors A_{tet}, B_{tet}, A_{tri}, and B_{tri} for calculating nodes 11-15 from nodes 1-10. (Lines 9 and 19, Column 7, Nagtegaal) One cannot apply the weighting factors from Nagtegaal to an 8-node hexahedral element, since Equation (1) in Nagtegaal requires 10 specific nodal coordinates of a tetrahedral element not for an 8-node hexahedral, 6-node pentahedral nor 4-node plane strain or axisymmetric element.

In addition, dependent claims 5, 10 and 15 are dependent upon respective independent claims 1, 6, and 11, and contain additional limitations further distinguish them from Nagtegaal or Hughes, viewed alone or in combination. Therefore, Claims 5, 10 and 15 shall be allowable for at least the reasons stated above with regard to independent claim 1.

SUMMARY

In view of the forgoing, Applicant believes that all claims now pending in this application are in condition for allowance. Early and favorable action is being respectfully solicited.

If there are any issues remaining which the Examiner believes could be resolved through either a Supplementary Response or an Examiner's Amendment, the Examiner is respectfully requested to contact the undersigned at (408)255-6853.

No fee is required for this amendment, if it is determined that a fee is due in connection with this paper, the Commissioner is hereby authorized to charge payment of any fees associated with this communication or credit any overpayment, to Deposit Account No. 553308, including any filing fees under 37 CFR 1.16 for presentation of extra claims and any patent application processing fees under 37 CFR 1.17.

Respectfully submitted,

I hereby certify that this correspondence is being transmitted to the Commissioner for Patents via the Office electronic filing system on the date stated below.

Date: July 10, 2007

Signature: /Roger H. Chu, Reg.# 52745/
Roger H. Chu

/Roger H. Chu, Reg.# 52745/

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